

NASA's use of human behavior models for concept development and evaluation

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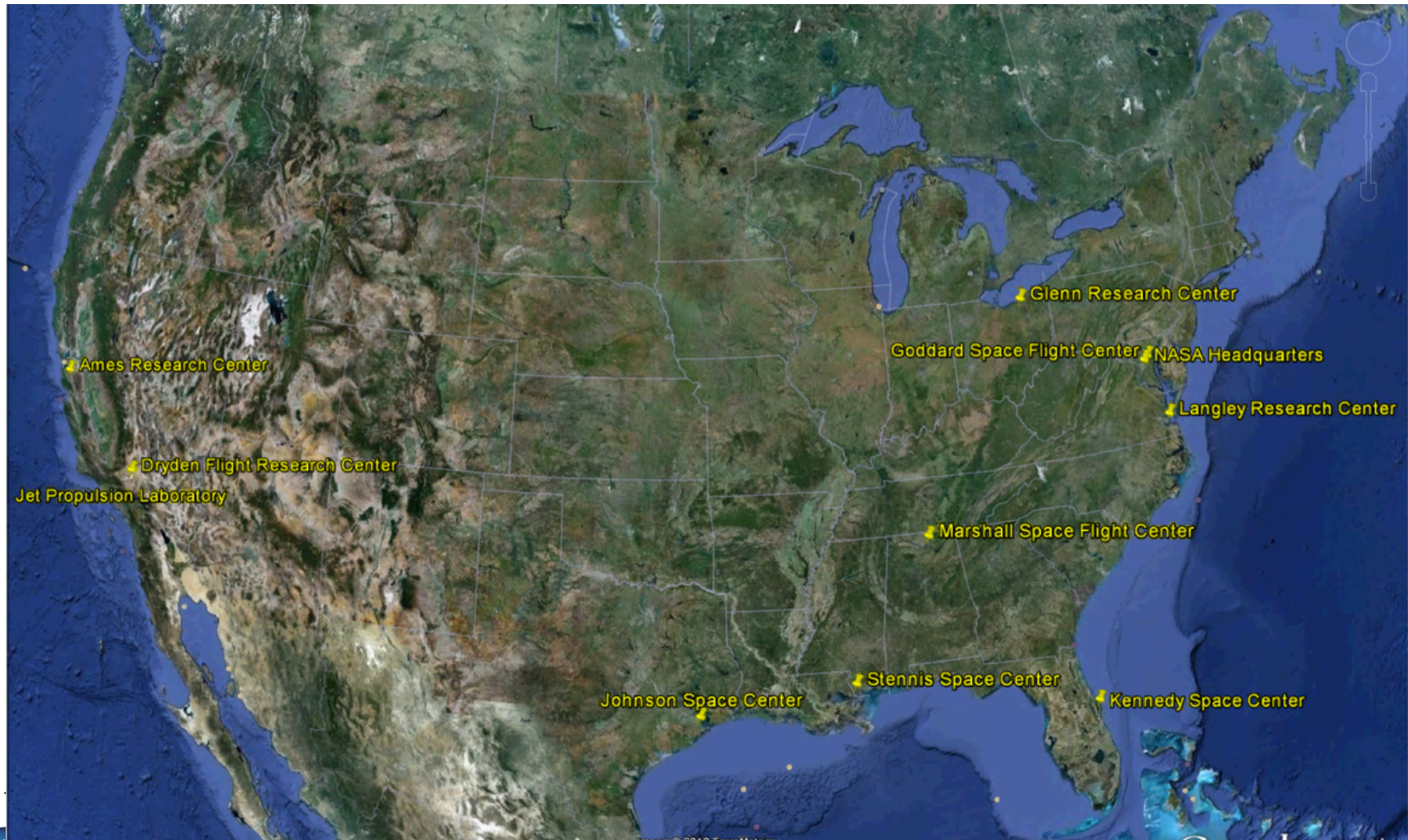
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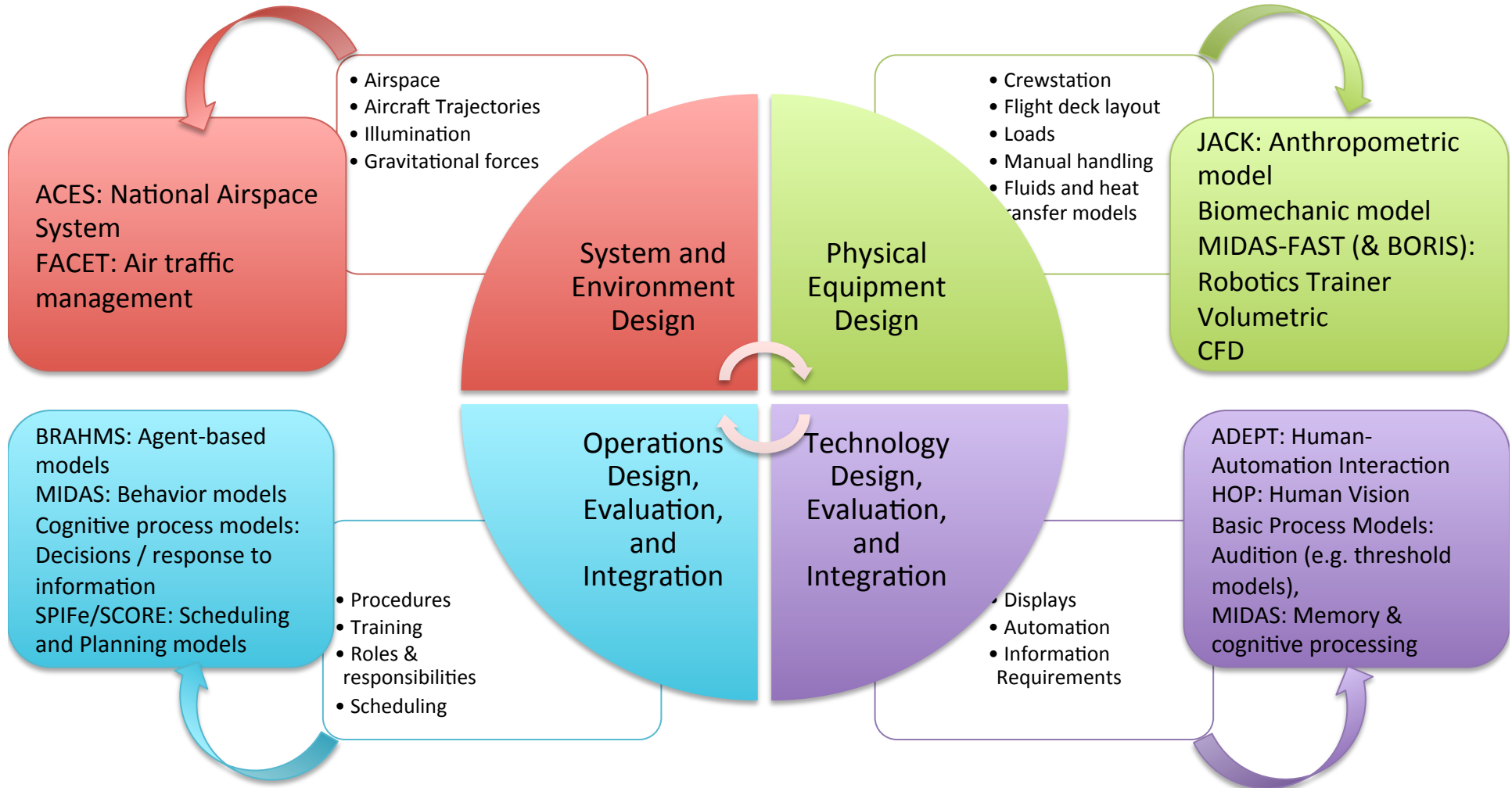
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- Modeling and simulation are critical to comprehensively study complex human-system designs
- Many different types of models exist at NASA
 - Human behavioral
 - Human performance
 - Anthropometric, biomechanic, volumetric
 - Information processing
 - Vision, auditory, memory, and other human processes
 - Task network
 - Physical structural (space launch vehicle, aircraft, crewstations, CAD/CAEs)
 - Airspace system
 - Weather
 - Airflow and other CFD
 - Physiological
 - Robotics and automation
 - Oxygen and blood flow
 - Scheduling



NASA Ames Human Modeling in System Design

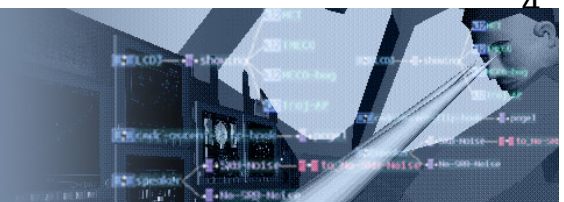


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NASA Ames HSI Research Areas

http://humansystems.arc.nasa.gov/techareas/tech_areas.php

Technical Area	Laboratory	Research Area
Human Computer Interaction (HCI)	HCI	Contribute to the development of better NASA software through careful application of iterative user research, interaction design, and usability
	Human Automation Interaction	ADEPT provides a tool for prototyping automation and associated interfaces, in an integrated tool that includes analyses to identify potential HAI vulnerabilities early in the design process
	Scheduling and Planning	Scheduling and Planning Interface for Exploration (SPIFe) toolkit for space missions that includes human constraints on mission operations
Human Performance Research	Advanced Controls and Displays	Research on haptics, speech recognition, visual perception, visual perception in space, adaptation to virtual environments, and acoustics
	Human Cognition	The mission of the Cognition Lab is to develop computational models for assessing throughput and error rates of human performance.
	Flight Cognition Lab	Studies the cognitive, team and organizational processes that underlie the performance of pilots, air traffic controllers, and other skilled professionals
	Intelligent Systems	Enhance mission safety and crew efficiency in next-generation spacecraft by evaluating the operational impacts of environmental stressors and by developing and testing advanced operations concepts and crew-vehicle interfaces.
	Man-machine Integration Design and Analysis System (MIDAS)	Develop human performance models of human-system interaction to predict operator performance along the measures of task performance and times, visual attention, workload, situation awareness
Integration and Training	Airspace Operations Laboratory (AOL)	Researches roles, responsibilities, and requirements for human operators and automation in future air traffic management (ATM) systems using human in the loop
	Human Centered Systems Laboratory (HCSL)	Focuses on mission safety and efficiency by developing innovative display technologies using both HITL and HPM methodologies

Human Performance Models



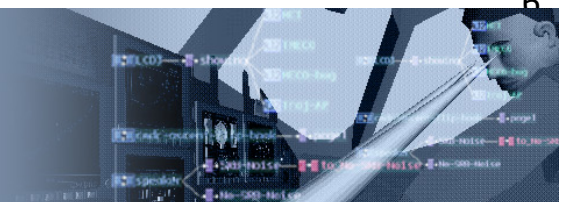
- Human Performance Models (HPMs) allow system designers the ability to model critical events that cannot be fully studied with empirical simulations
- Models can be used to provide estimates of human-system performance when the concepts, technologies, or automation are too new, difficult, or dangerous for the human operator
- Model validity is a paramount concern when predictions are generated to evaluate candidate NextGen operations

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Motivation:

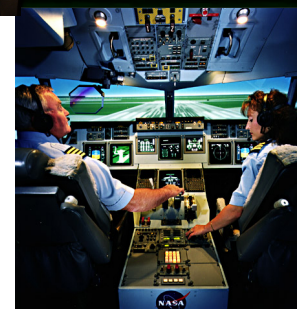
NextGen Technology Design, Evaluation, and Integration

• NextGen Characteristics:

- More data available to the flight deck
 - e.g., weather, wake, traffic trajectory projections, etc.
- More precise and closely coordinated operations
 - e.g., self-separation, closely spaced parallel operations, RNAV/RNP
- More tasks are automated
 - Pilot increasingly placed in a monitoring role
- Potential for increased workload, decreased situation awareness, increased demand for shared attentional resources

• Evaluating NextGen Concepts:

- Must consider pilots' capabilities when designing / evaluating NextGen procedures, operations, roles / responsibilities and the information requirements
- Failure to do so will leave the pilots, and thus the entire aviation system, vulnerable to error

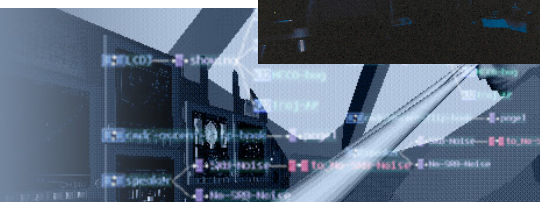


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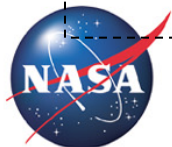
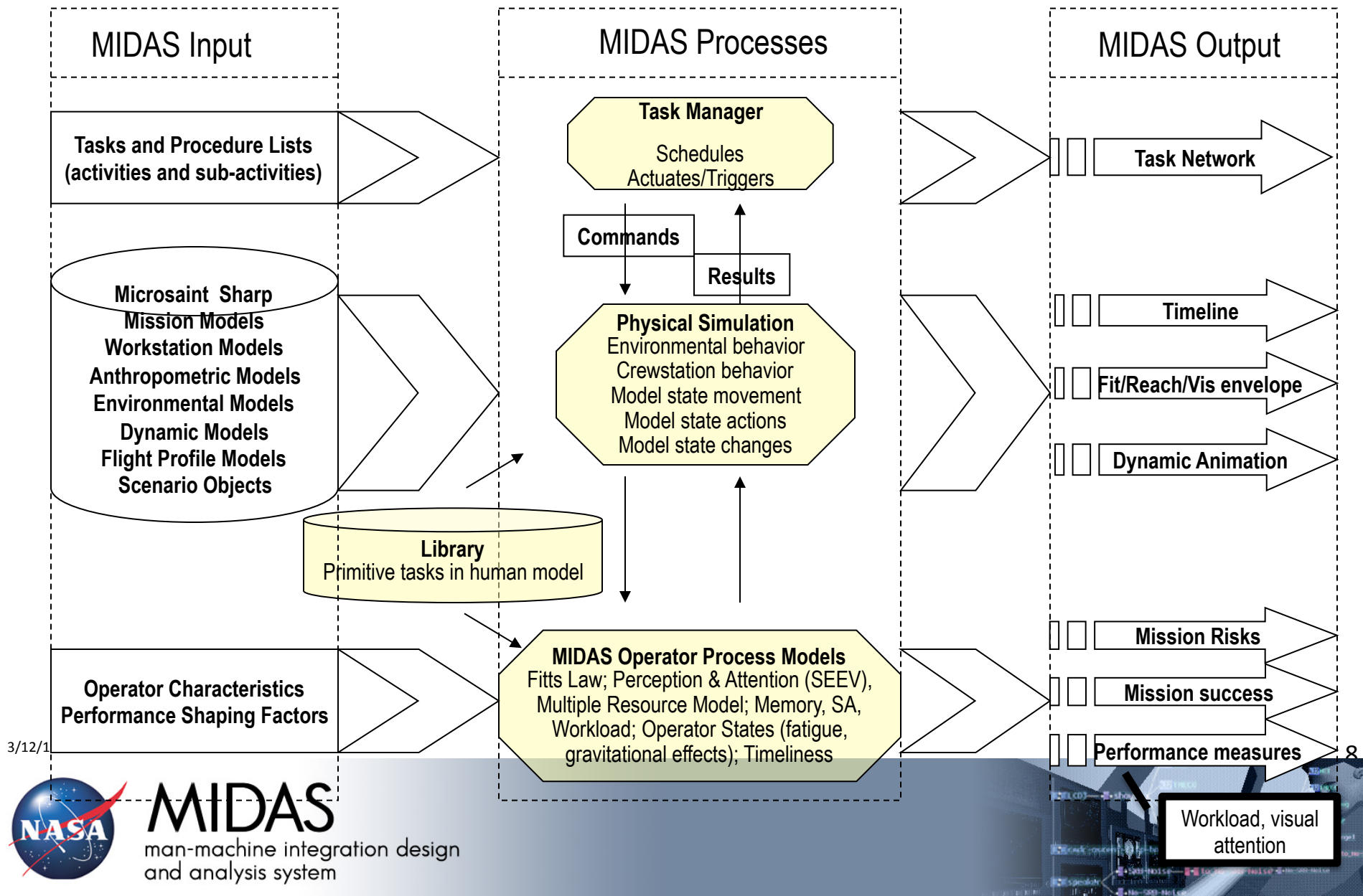


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MIDAS v5 Structures



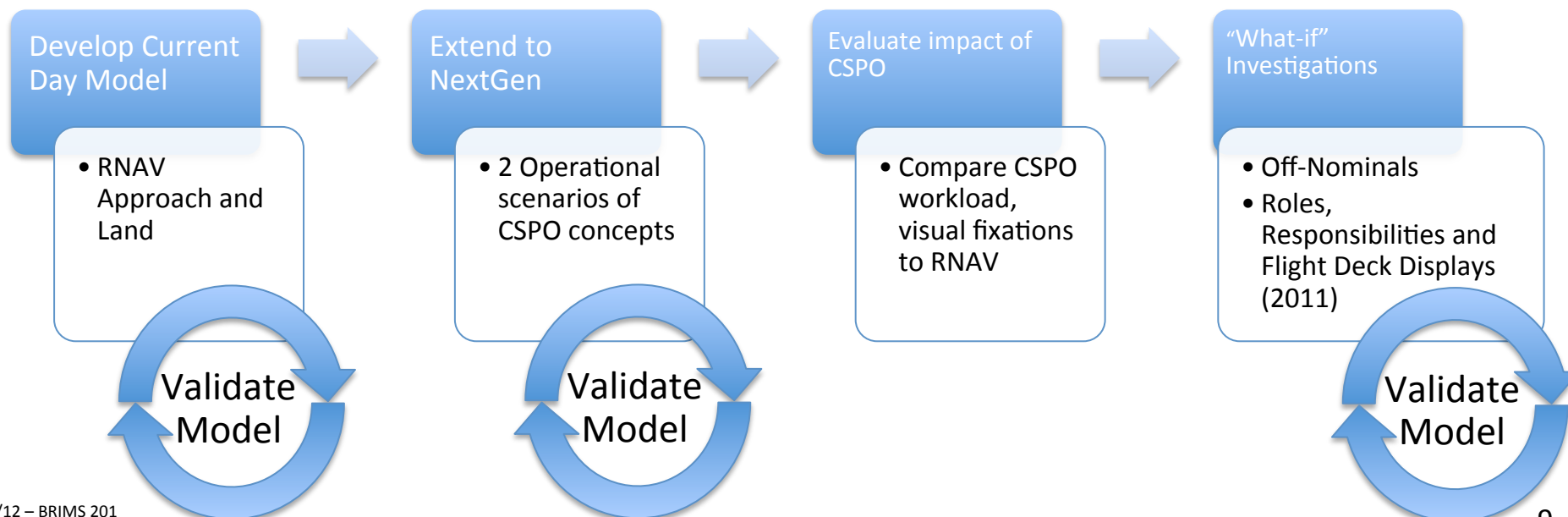
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Workload, visual
attention

CSPO Project Overview

- Objective
 - Develop valid HPMs of approach and land operations, use these models to evaluate candidate NextGen concepts (Closely Space Parallel Operations, CSPO), develop guidelines regarding flight deck displays and pilot roles and responsibilities



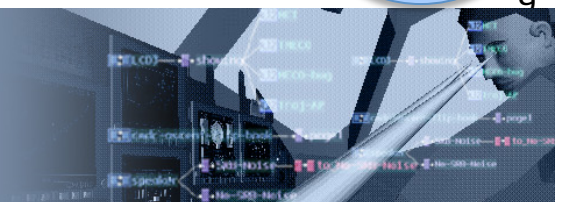
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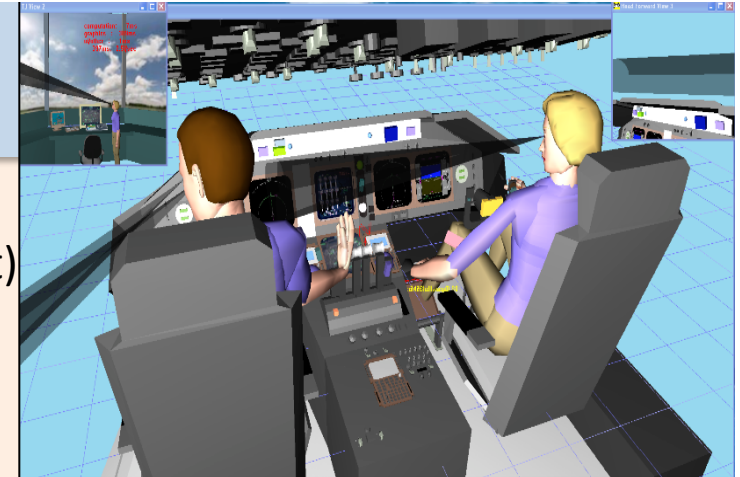
Gore, B.F., Hooey, B.L., & Foyle, D.C. (BRIMS 2011, March 21-26).



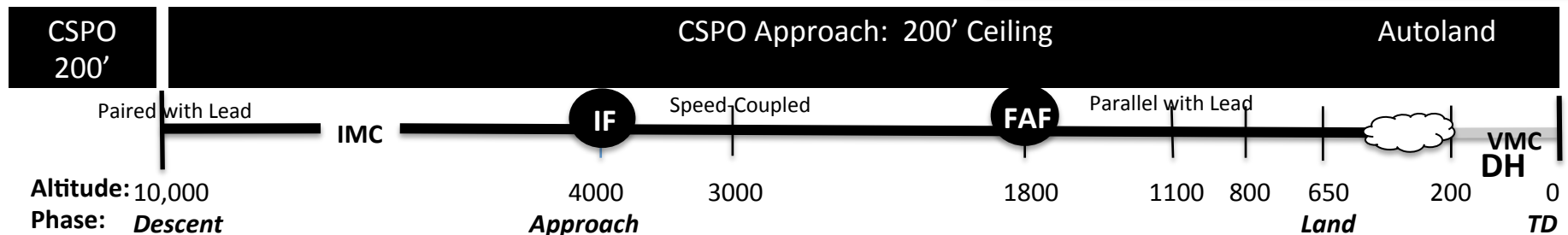
Evaluating NextGen Closely Spaced Parallel Operations Concepts with Validated Human Performance Models

Model Development and Validation

- Develop RNAV model based on task analyses (SME input)
- Validate model inputs, processes and outputs
- Extend RNAV model to two CSPO Concepts
- Evaluate: Pilot-ATC separation responsibility, Wake Information Requirements, Spacing Management Information Requirements
- Implications based on: Pilot workload, visual attention event/alert detection response times



MIDAS v5, a human performance model of the flight deck environment, pilots' workflow and cognitive processes.



1. Develop and validate model (BRIMS 2010, 2011)	2. Evaluate off-nominal events (BRIMS 2010, 2011)	3. Evaluate roles and responsibilities (AHFE 2012)	4. Evaluate information requirements
- RNAV scenario + 2 CSPO operational scenarios - Validated model - <u>inputs</u> (Focus groups) - <u>processes</u> (Literature) - <u>outputs</u> (HITL data)	- Weather (high wind) - RNP Loss - FMS Failure - Aircraft off runway	- Pilot-pilot roles (Allocation of task, monitoring workload) - Pilot-ATC roles (Conflict detection and resolution)	- Flight deck information required to support early conflict detection and safe response - Wake format and location - Spacing Automation style and format

CSPO Findings and Implications

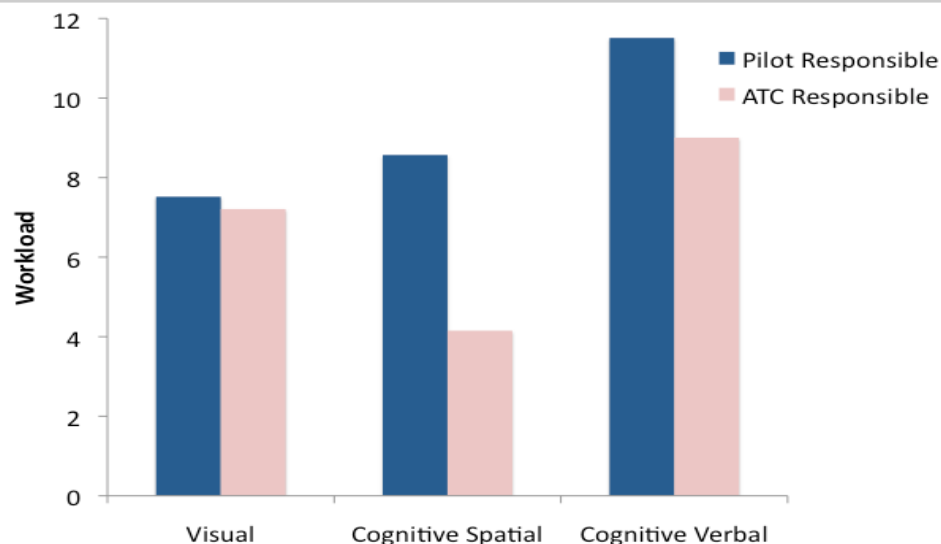
Flight Deck Requirements for:

1. ATC-Pilot Roles and responsibilities: ATC vs Pilot responsibility for separation
2. Alert styles for wake and blunder threats: One-stage vs two-stage alerts
3. Wake display technology: Format (predicted vs real-time), Location (PFD, Nav Display, or Both)
4. Spacing management automation: Style (Current vs NextGen), Location (PFD, Nav Display, or Both)

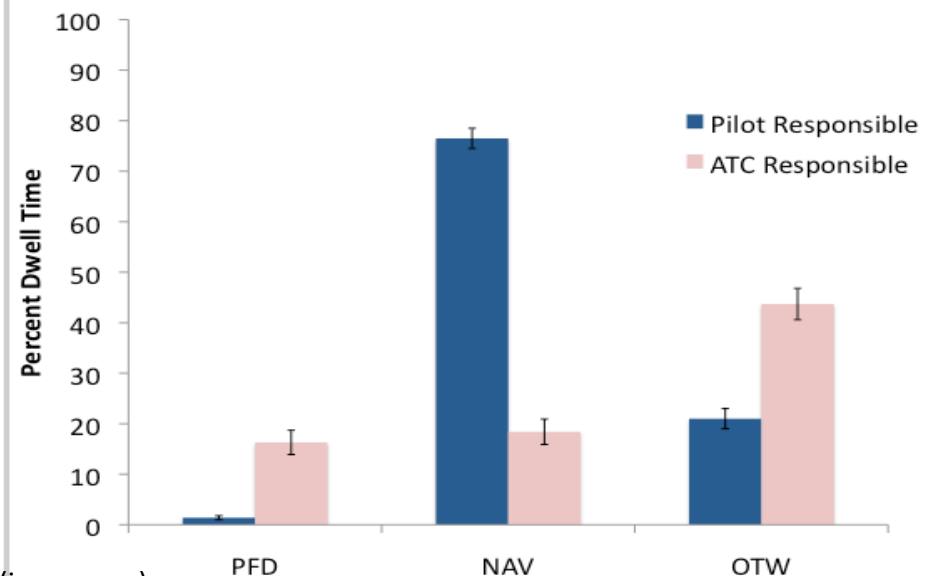
Evaluating ATC-Pilot Roles and Responsibility: Separation Delegation

- Compared Current-day (ATC responsible for separation) with NextGen (Pilot responsible for separation)
- Model predicted slightly faster emergency escape maneuvers when Pilot's are responsible (.3 sec), BUT...

Higher workload when pilots are responsible for separation



Less balanced pilot scan when pilots are responsible for separation



Hooey, Gore, Mahlstedt, & Foyle, (2012); Gore, Hooey, Mahlstedt, Foyle (in process)

Summary

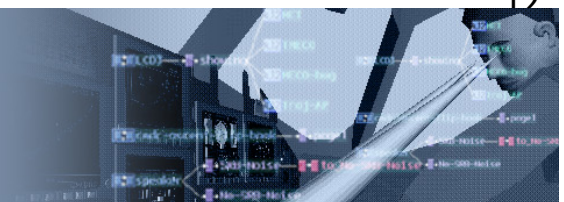
1. HPMs such as MIDAS can be used to evaluate:
 - Pilot/ATC roles and responsibilities and function allocation
 - Technology development and integration
 - Error or safety vulnerabilities
 - Procedures and training needs
2. HPMs such as MIDAS can be applied to other:
 - Phases of flight, (e.g. aviation - arrivals, enroute, departures, taxi and their transitions; space - ascent, descent; ISS operations)
 - Flight deck technologies (e.g., SVS/EVS; CDTI; EFBs; MFDs;)
 - Information requirements manipulations
 - Concept of Operations evaluations
 - Space operations (e.g. ISS and CEV/SLS procedure design and evaluation)
 - Human-automation interaction domains

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